RELATIVE LOCATION
AND INDUSTRIAL GROWTH

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TABLE OF CONTENTS

Chapter | Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

The location of industry is the result of a collection of decisions based on a variety of economic circumstances and personal objectives. Industrial location analysis is defined as the study of the spatial arrangement of industry resulting from those decisions. Although the distribution of industry is the sum of many decisions, a distinctive areal pattern often seems to occur as many industrialists weigh the same locational factors heavily. As an understanding of the reasons behind the observed patterns is increased, competency in the ability to predict those patterns is also enhanced, and, in the capitalistic tradition, individuals having increased knowledge can manipulate the rationale behind the spatial patterns for personal gain.

This investigation assesses the importance of relative location to industrial growth. Relative location is defined in terms of potential surfaces for a set of small cities with respect to various economic characteristics of large urban concentrations. In general terms, potential is a summation of interactions between a place and alternate locations when interaction is defined by population mass and a friction against interaction caused by the distance between places. In this thesis, potential is an aggregate measure of accessibility[1] to economic characteristics such as market, materials, capital, services, and entrepreneurial awareness. Because industry is located in accordance with various internal economic factors,[2] potential is an excellent method to measure rela-

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[1]Ray, D.M. Market Potential and Economic Shadow (Chicago: University of Chicago, 1965) pg. 26.
[2]Ibid., pg. 25.

tive location. In addition, the potential concept is used to develop maps for analyzing the role of larger population and activity agglomerations in relation to industrial growth in smaller cities.

Background

Geographers were reluctant to drift from the traditional emphasis of empirical observation, so it seems unusual that in 1926, a geographer, Richard Hartshorne, would advance one of the most fundamental concepts of industrial location analysis.[3] Hartshorne suggested that relative location was a more important influence on the location of economic activity than were physical factors such as soil, drainage, and relief. Economists also recognized the importance of location for industrial growth. As early as 1909, Alfred Weber conceived of an optimum location theory where aggregate cost was minimized given the areal pattern of locational factors such as labor, market, raw materials, and power.[4]

Relative location has been recognized as an important variable in industrial location analysis throughout this century. Initially, locations near navigable waterways or large markets were almost essential, but because technological innovations have significantly reduced the friction of distance, such locations are no longer as significant. Economic systems are dynamic, particularly because of the array of improving technologies, and as a result, industry is becoming more "footloose," or industrial locations are no longer restrained by any single factor. This suggests that

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[3] Smith, David M. Industrial Location, (New York, John Wiley & Sons Inc., 1971), pg. 98.

[4] Weber, Alfred The Theory of Location of Industries, (translated by Carl J. Friedrich, Chicago, University of Chicago Press, 1929).

for an increasing number of industries, the dominant location factors are changing. For example, in 1954, Edward Ullman noted that market orientation for industry had apparently overbalanced movement to raw materials.[5] He attributed this change to improvements in technology, transportation, and economies of scale. Another example, as noted by Dorf and Harren, is the decentralization of manufacturing from urban to more rural areas since the 1950's.[6] The movement of New England's textile industries to rural southern United States is often cited as an example of this "trend." But one must not be misled into thinking that this movement is confined to the textile industry. Harren notes, "An outstanding characteristic of industrial decentralization in the 1960's has been the highly diversified types of industry moving into . . . partly rural communities."[7]

Locational analysts of today are in agreement with Edward Ullman's opinion that, as an attracting force for industry, markets are of increasing significance in relation to considerations such as materials and labor.[8] No longer is it necessary for firms to locate at the raw material site or source of power, and industry is showing a preference for locations near or in large urban concentrations where they enjoy a large consumer body, available capital, industrial "know-how," a trained labor force, and all those components associated with economies of urbanization. Even though industry has been decentralizing in recent decades, the importance of these large

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[5] Ullman, Edward L. "Amenities as a Factor in Regional Growth," The Geographical Review, Vol. 44, (1954), pg. 127.

[6] Dorf, R. An Analysis of Manufacturing Location Factors..., (An unpublished dissertation, Dept of Economics, Kansas State University) 1976. Harren, Claude C., "Rural Industrial Growth in the 1960's," American Journal of Agriculture Economics, August, 1970.

[7] Harren, pg. 433.

[8] Burrows, J., C.E. Metcalf and J.B. Kaler Industrial Location in the United States (Lexington, Mass., Heath Lexington Books 1971). Also see Dorf and David Smith for supporting comments.

urban centers for industrial location remains strong. This indicated that a location with proximity to large population and activity agglomerations remains as a poignant location variable to new location seeking firms. This point has been statistically supported in that variables representing this form of relative location have yielded high correlations in recent studies done by Dorf and Burrows.[9] I am in agreement with these studies in that I too recognize the importance of a favorable location with respect to large centers as an advantage for industrial growth, but I take exception with the manner in which the location variables have been measured. The accepted method has been to measure the distance to the single nearest large city having a specified minimum population (studies have differed with city size varying from 50,000 to 1,000,000 persons). A hypothetical case will clearly show why this is an inadequate way to measure relative location to large urban concentrations (Figure 1.1).

Figure 1.1

HYPOTHETICAL LOCATION SITUATION

[9]See especially pgs. 8 and 128-131 in Dorf.

Using the before mentioned method, both city 'A' and city 'B' are given equal location values when 'A' clearly holds a more favorable position with respect to its accessibility to all the urban concentrations. A method which would weigh location relative to all large places within a larger region would be far more valuable than one that considers only distance to the nearest large city.

Statement of the Problem

This study will investigate the degree to which industrial growth in small cities is associated with their location relative to larger, dominant urban concentrations. The variation in industrial growth between small cities will be explained in terms of location potential expressed in the form of potential surfaces. The industrial location potential surfaces will be described for several variables, to include population, retail sales, payroll in selected assembling and fabricating industries, and value added by manufacturing (these variables are discussed in Chapter Three). A comparison will be made between the potential surfaces and industrial growth in small cities measured by both change in industrial employment (as a raw figure and on a per capita basis) and change in the number of industries, to determine (1) the degree of the relationship between relative location to large cities and industrial growth in smaller cities; and (2) which of the potential variables contributes most to that relationship. By comparing this model with the portion of reality with which we are concerned, we can increase our perception and comprehension of the nature and significance of those "real" attributes examined.

Justification

There are an estimated 1,500 new plants located in the United States each year and over 15,000 area organizations, such as Chamber of Commerce groups, competing for those locations.[10] By isolating and studying each of the attributes important to the location of those industries, the competing organizations can be made more aware of their positions relative to other competing organizations. This study will relate two bits of information to these organizations: (1) the importance of location to industrial growth; and (2) the relative worth of individual locations. This knowledge can be valuable to organizations with poor locations as well as organizations with good locations. In the first case, decisions can be made in an attempt to offset a poor location, such as the construction of an industrial park; in the second case, organizations knowing their locations are good can advertise that fact. Furthermore, by isolating variables relating to the occurrence of phenomena on the landscape, we can better understand the role each plays in the changing locational pattern. By studying each component, this understanding is enhanced and the capability to predict and plan future spatial patterns is also improved.

Geographers can play an important part in the process involved in isolating the important elements in complex location situations. This study is geographic in its scope because it focuses on a component that has traditionally been associated with geography, i.e., relative location. According to William Pattison, the spatial tradition, in-

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[10]Clark, Harry W. "Prospecting" in Guide to Industrial Development (Prentice-Hall, New Jersey), pg. 146.

cludes the study of distance, form, direction, and position, and has made "deep penetration" in geography from its very beginning.[11]

Expected Results

It is expected that the measures of industrial potential will be positively associated with industrial change. In other words, I expect to find that small cities with good locations with respect to large urban centers will experience more industrial growth than cities less favorably located. In addition, if the earlier discussion on decentralization has any merit, the potential surfaces measured in terms of industrial payroll and value added by manufacturing may prove to be the most significant in explaining industrial growth in small cities. Greater potential values for these variables will suggest a better chance for industrial decentralization. This would support the theory that industry is decentralizing and suggest that places with large potential values, indicating good accessibility to large centers, benefit from large center industrial spinoffs.

Plan of Study

The aim of this chapter has been to develop the purpose of this study and to establish a foundation from which to understand what follows. Chapter Two discusses the geographer's role in understanding economic systems and locational analysis. Chapter Three explains the method of approach, including a discussion of the sample cities, study area, and

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[11] Pattison, William D. "The Four Traditions of Geography" in Durrenberger's Geographical Research and Writing, (New York, Thomas Y. Crowell Co., 1971), pg. 85.

the techniques of analysis, which include potential models, regression analysis, and correlation analysis. Chapter Four contains the results and analysis of the statistical tests. Finally, Chapter Five concludes and summarizes the importance relative location plays on industrial growth and the significance of the potential variables selected.

CHAPTER TWO

ECONOMIC SYSTEMS AND LOCATION ANALYSIS

Geographers have not always been involved in theoretical studies or studies involving the use of models. Most lay-persons would not associate much of the work being done in geography today with their perception of the discipline. This chapter will acquaint the reader with the more theoretical tones of today's economic geography, familiarizing him with the role of geography in the field location analysis.

Economic Geography

Since the 1950's, geographers have been emphasizing their role as social scientists and, although the business of a scientist is exceedingly complex, an important part of his work, as stated by Hall and Fagen, is the "analysis of systems, synthesis of systems, and evaluation of systems operations."[1] An area of interest to economic geographers is understanding economic systems. David Smith has gone so far as to say that "an understanding of the nature and operation of economic systems is one of the most important contemporary intellectual requirements."[2] Any system may be loosely defined as a set of objects with relationships between themselves and their attributes.[3] An economic system, then, is

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[1] Hall, AD. and R.E. Fagen "Definition of A System," Systems Engineering (New York, Bell Telephone Laboratories, 1971), pg. 91.

[2] Smith, David M. Industrial Location (New York, John Wiley and Sons Inc., 1971), pg. 1.

[3] Hall and Fagen, op cit, pg. 81.

fundamentally an organizational structure through which people attempt to acquire and disperse scarce resources efficiently and in accordance with their needs.[4] Economic activities and the connections between them make up the system. Although these activities have physical expression (factories, roads, mines, etc), it is the interaction and linkages to human activities that make up an economic system. When viewing the world as a system, the major emphasis is on wholeness and interdependence. It is this focus on functional interdependence that makes the systems approach so appealing to geography.

Traditionally, economic systems are broken down into three categories: production, consumption, and exchange. Inevitably, there is a spatial disparity between the motivators and regulators of economic systems, supply and demand. An interaction must take place between the points of supply and the places of demand for consumption to occur, and the interaction is therefore affected by distance. This is an important point because, although there is somewhat of a nebulous borderland between economics and economic geography, the study of the spatial aspects of economic systems is primarily a field of inquiry for the economic geographer.*

An economic system is also a human social system because it is made up of human activities and the linkages that connect them, and is subject to the attitudes, perceptions, motivations, and expectations of people.

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[4]Lloyd, Peter E. and Peter Dicken Location in Space: A Theoretical Approach to Economic Geography (New York, Harper & Row, 1972), pg. 1.

*There are many economists concerned explicitly with location and space and it has been their early contributions which have been the most significant in contributing to an understanding of the spatial dimension of economic systems.

Therefore, any spatial pattern that occurs within an economic system is the product of many human decisions. This clearly implies that economic geography is a behavioral science with its accent on the spatial dimension.[5] Furthermore, as scientists, economic geographers should concern themselves with the formulation of general principles. Unfortunately, this has not proven to be the case and, in the past, geographers have been content to explain economic spatial patterns as they relate to the physical environment or with describing them through a historic perspective. Traditionally, geographers have been inclined toward empirical observation and, although this has led to an impressive inventory of factual knowledge, it has done little in the way of adding geographical contributions to theory. Ballabon stated the problem best: "Economic geography has been short on theory and long on facts."[6]

Since the quantitative revolution of the 1950's, this emphasis has changed. More and more frequently geographers are asking why spatial patterns occur and this has led to a great deal of current work being devoted to the development of theories and models. Models simplify the complexities of real world problems and provide a basis for predicting real world spatial patterns. Many geographers have been adamant in their stand against the use of models in geography, arguing that no model can represent reality. A well-known mathematician, W. Feller, answers this opposition to the use of models:

> "As for practical usefulness, it should be borne in mind that for a mathematical theory to be applicable, it is by no means necessary that it be able to provide accurate models of observed phenomena. Very often in

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[5] Lloyd and Dicken, op cit, pg. 2.

[6] Ballabon, M.B., "Putting the 'Economic' in Economic Geography," Economic Geography (33, 1957), pg. 217.

> applications, the constructive role of mathematical theories is less important than the economy of thought and experimentation resulting from the ease with which the qualitatively reasonably working hypotheses can be eliminated by mathematical arguments.... In this way undecisive qualitative arguments are supplemented by more convincing quantitative analyses."[7]

Although no model can recreate reality, it can aid or direct us toward an immediate understanding of the problem as well as help us to ask the right questions. In light of sound arguments such as this, regression equations, factor analysis, t-tests, and many other statistical techniques have become commonplace in the economic geographers repertoire.

Economic geography is a very broad field including agriculture, mining, manufacturing, the provision of services, and much more. The many diverse fields under the single heading of economic spatial analysis has led to its fragmentation into many more specialized topics. It is partly because of this topical specialization that industrial location analysis has been recognized as a distinct field within economic geography. According to David Smith, "The study of industrial location is clearly one of the most important branches of economic geography."[8]

Geographical Contributions to Location Theory

George Renner

Until the 1950's, geographers were reticent to provide general principles of industrial location. For the most part they were still predisposed toward empirical investigation. Although this led to a tremendous body of recorded fact, the contributions to the general understanding of

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[7]W. Feller, in Hall and Fagan, op cit, pg. 88.

[8]Smith, op cit, pg. 2.

industrial location were limited. George Renner was a major exception to this norm. In 1947, he classified industry into four categories: extractive, reproductive, fabricative and facilitive. He further indicated that if any of these industry types were to be undertaken, six essential ingredients had to be available: raw materials, market, labor, power, capital, and transportation. From these concepts he formulated a principle of industrial location:

> "An industry tends to locate at a point which provides optimum access to its ingredients or component elements. If all these component elements be juxtaposed, the location of industry is predetermined. If, however, they occur widely separated, the industry is so located as to be most accessible to that element which would be the most expensive or difficult to transport, and which, therefore, becomes the locative factor for the industry in question."[9]

Although the general principle acts differently for each of the four industry types, it is applicable to each and from it Renner developed so-called "laws of location." For example, fabricative industries, or manufacturing, would behave according to the "law of location for fabricative industries," which is as follows: If the industry uses perishable or condensible raw materials, that industry will locate at the raw material site; but, if the industry through processing, makes the raw materials more fragile, perishable, or adds weight or bulk, then the industry will locate at the market place. Furthermore, if labor or power are the major contributors in the fabricating process, then the industry will seek a site where those costs are at a minimum.

Renner not only classified industry, he also classified the relationships between industries. He likened industrial groupings to organismic

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[9] Renner, G.J. "Geography of Industrial Localization," Economic Geography, 23, pg. 169.

life in what he termed "industrial symbiosis." Using this technique, he described the way industry coexisted. "Disjunctive symbiosis" was the term Renner applied when unlike industries existed together without an "organic" connection; an example would be labor intensive fabricative industries locating near the Applachian coal fields and employing the wives of miners. "Conjunctive symbiosis" occurred when industries co-existed with an "organic" connection; one industry using products directly from another. If the symbiotic relationship led to a large industrial concentration, the concentration was labled "coindustrialization."

Even though the symbiotic relationships were only elaborate discussions of externalities and agglomeration tendencies, Renner's paper was a valuable statement in that it served as a springboard from which economic geographers could move into the theoretical economics of the time.

E.M. Rawstron

Another ten years passed before a geographer made an important contribution in the endeavor to improve the general understanding of industrial location. In 1958, E.M. Rawstron published a short paper in which he explored the extent to which location was restricted if economic viability was to be achieved.[10] The paper offered three principles governing industrial location: the physical restriction, the economic restriction and the technical restriction. A physical restriction, such as a natural limitation like the presence of an iron ore deposit, occurs only when a natural resource is to be produced, and therefore, principally concerns the extractive industries. This restriction applies only in

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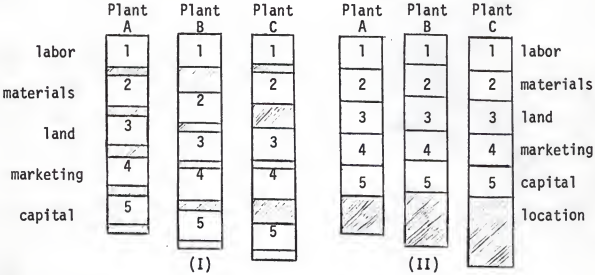
[10] Rawstron, E.M. "Three Principles of Industrial Location," Transactions and Papers (1958, IBG, 25), pg. 132-142.

that it limits the areas in which one can locate. Restrictions on the quantity of output or precise mine locations are subject to economic restrictions.

David Smith suggests that it is the economic restriction that makes Rawstron's contribution notable.[11] Smith feels this principle is important because it involves spatial margins of profitability where costs become too great for industrial location to be economically viable; costs to the industry involving expenditures on labor, materials, marketing, land, and capital. Consider the case of three plants at three locations, all requiring equal quantities by value of the five principle cost components, labor, materials, land, marketing, and capital, but the cost of each component varying at each location (see Figure 2.1 I). The shaded portion of the bar graphs, associated with each of the cost inputs, represents the additional locational cost for each component. Figure 2.1 II exhibits the total locational cost of each place and clearly operation at 'A' will be cheapest while operation at 'C' will be most expensive.

FIGURE 2.1
THE EFFECT OF LOCATION ON COST STRUCTURE



Source: Rawstron, 1958, 136-137, figures 1 and 2.

[11]See Smith, op cit.

The last of Rawstron's principles, technical restrictions, was considered to be important only as technical improvements occurred less frequently for the industrialist. At that time, locational economics, such as abundant cheap labor or large accessible markets became more important.

Rawstron's contribution was a valuable one to the geographical literature because it was a general concept which suggests the narrowing down of a locational choice by successively more stringent restrictive location factors. Spatial variations in the cost components lead to the imposition of limits, beyond which economic operation is no longer viable. Even though his discussion on economic limits seems to have been an extension and restatement of Alfred Weber's theory of critical isodapanes,[12] it was a valuable contribution because it heightened the geographer's awareness of such existing theories. By stressing the general concept of spatial margins of viability, Rawstron insured location theory as a field of endeavor for geographers.

The Behavioral Approach

While economic geographers like Renner and Rawstron were increasing their awareness of the economic optimization theories of economists, other geographers avoided theorizing about industrial location. They argued that decisions couched in attitudes, perceptions, motivations, habits, and expectations could not possibly lead to economic optimization and because of the apparent randomness of human decision making, generalizations could not be drawn. Questions such as: "Will the manufacturer lo-

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[12] Weber, A. Alfred Weber's Theory of the Location of Industries (Translated by C.J. Friedrich, University of Chicago Press, Chicago, 1929).

cate in accordance with economic incentives or to be near his favorite golf course?" demonstrated the possibility for random decision making. Because location decisions are made by people with imperfect knowledge, geographers have more recently been stressing the behavioral approach which emphasizes the suboptimal nature of human decisions. One of the most thorough discussions to date on the behavioral approach is the two volume study by Allen Pred.[13] Pred suggests that people have both limited knowledge and limited power to use that knowledge. He states: "Every locational decision is viewed as occurring under conditions of varying information and ability, ranging, at least theoretically, from null to perfect knowledge of all alternatives, and as being governed by varying abilities of the decision maker."[14] Pred submits that every entrepreneur holds a position in what he terms the behavioral matrix (see Figure 2.2).

FIGURE 2.2
THE BEHAVIORAL MATRIX

Ability to Use Information
toward an Optimal Solution

$$
\begin{array}{c c}
 & \xrightarrow{\hspace{4cm}} \\
\begin{array}{c}\text{Quantity}\\ \text{and}\\ \text{Quality}\\ \text{of}\\ \text{Information}\end{array} \quad \text{Toward Perfect Knowledge} \downarrow &
\begin{array}{|cccccccc|}
\hline
B_{11} & B_{12} & B_{13} & \cdot & \cdot & \cdot & \cdot & B_{1n} \\
B_{21} & B_{22} & B_{23} & \cdot & \cdot & \cdot & \cdot & B_{2n} \\
B_{31} & B_{32} & B_{33} & \cdot & \cdot & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\
\cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\
B_{n1} & B_{n2} & B_{n3} & \cdot & \cdot & \cdot & \cdot & B_{nn} \\
\hline
\end{array}
\end{array}
$$

Source: Pred, 1967, 25, figure 1.

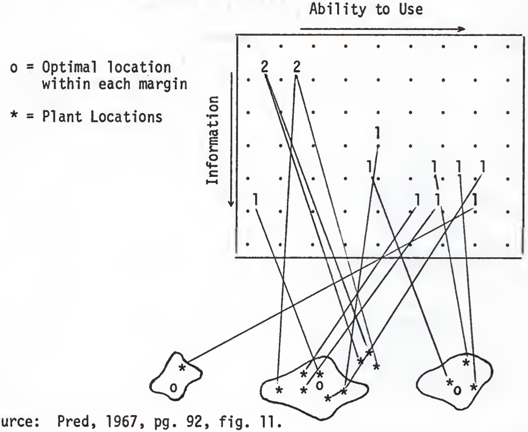
[13] Pred, Allen Behavior and Location: Foundations for a Geographic and Dynamic Location Theory (Part 1 & 2, Lund Studies in Geography, Series B, 27 & 28, 1967).

[14] Ibid., pg. 24.

An individual or entrepreneur holding a position in the upper left corner would have the least available information and ability to use it; while an individual near the lower right corner would have near perfect knowledge and ability to use that knowledge when making a location decision. The matrix is a probability matrix; an entrepreneur holding a position in the upper left corner might make a near optimal location decision but the probability of that event occurring would be relatively small, and it follows that the opposite would be true for an individual with a position in the lower right corner.

This matrix is put forth as an interpretive device to aid in the understanding of real life suboptimal decision making. There may be a degree of randomness in the resulting decisions but the argument is that there will be a regularity occurring in location decisions in general. Figure 2.3 on the following page illustrates this point. The open circles represent optimum locations which are enclosed by isodapanes or spatial margins of profitability, as suggested by Rawstron. The location decisions of thirteen firms are signified by the black asterisks, each of which is connected to the position in the matrix which reflects the decision making ability involved in each locational decision. As can be seen, firms in the upper left corner of the matrix generally make less desirable decisions than those near the lower right corner. But the element of randomness is still apparent as shown by the single dot within the spatial margin of profitability originating from a position of poor knowledge and ability to use that knowledge. Note, however, that the position obtained is very near the margin (critical isodapane).

FIGURE 2.3
THE BEHAVIORAL MATRIX AND LOCATION DECISIONS



Source: Pred, 1967, pg. 92, fig. 11.

Pred submits that the behavioral matrix is only a statement of the obvious[15] but, as David Smith supports, "it is a useful way of conceptualizing the effect of imperfections in the ability of the entrepreneur and the information available to him."[16]

Despite advances, made by Renner, Rawstron, and Pred, and even with an increased use of quantitative methods, geographers still have made little progress toward generalizations and theories of industrial location analysis.[17] One need only consult the detailed bibliography of Stevens

[15] Pred, op cit, pg. 121.
[16] Smith, op cit, pg. 108.
[17] Ibid.

and Brackett[18] to realize the void where theoretical contributions by geographers might be. Research has continued with improved empirical geographic research contributing to the development of generalizations, but actual theoretical developments have been, as those of Renner and Rawstron, restatements and extensions of existing economic location theories. There has been progress made through borrowed concepts and models from disciplines other than economics as well. For example, the gravity model developed in physics has important implications for industrial location analysis, and an extension of it will be used and explained later in this study. But as yet, inspiring new geographical theories on industrial location analysis have not been discovered.

Notwithstanding recent emphases on theorizing, the geographer is still making important contributions based on observations which should not be overlooked. One such example is the generalizations made as a result of John Thompson's empirical investigations in New England.[19] From those observations, he developed several "theories" concerning manufacturing activity. His Cycle Theory holds that once a manufacturing area is established, it goes through a predicted sequence of changes. The Differential Growth Theory suggests that as an industrial society becomes more affluent, its demand for certain products exceeds that for others. The Concentration Theory stipulates that certain manufacturing activities have strong attractions for one another and will concentrate

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[18] Stevens, B.H. and C.A. Brackett, Industrial Location: A Review and Annotated Bibliography of Theoretical, Empirical and Case Studies, (Bibliography Series 3, Regional Science Research Institute, Philadelphia, 1967).

[19] Thompson, John H. "Some Theoretical Considerations for Manufacturing Geography," Economic Geography (42, 1966), pg. 356-365.

in a hierarchial fashion; the Agglomeration Theory holds that industry will concentrate in large urban places to avail themselves of the wide range of goods, services, and other economic advantages available; and finally, the Changing Role Theory states that the role and importance of manufacturing in an area or region changes as development progresses.

The contributions being made by geographers need not be underemphasized as the theories such as Thompson and Pred are useful generalizations of observed occurrences. The increased use of sophisicated statistical techniques on empirical investigations has supported the geographer's bias toward understanding real world spatial patterns. The behavioral approach and systems theory currently in vogue with geographers may not prove to yield adequate alternatives to existing economic location theory, but they provide something other than the profit maximizing rationale of that approach.

Summary

In Chapter One it was suggested that industry has been decentralizing from the country's large urban centers over the past twenty to thirty years. Further, as Edward Ullman has stated, because of technological innovations, particularly in transportation, industry is no longer tied to natural resource locations. Given these statements, questions concerning the worth of both Renner's and Rawstron's generalizations on industrial location arise. Are the economic optimizing theories worthy of the acclaim they have received?

Such questions spawned the behavioralist view proclaimed by Pred. It is obvious that whenever an imperfect decision maker is involved, imperfect decisions will result. And, as the behavioralists are quick to point out,

human decisions are subject to personal biases and perceptions. These may be fundamental points in reaching an understanding of the decentralization of industry. Because technology permits, and because people are not an economic optimizing creature, industrial entrepreneurs have recently been seeking not the optimal location, but one where open space and a rural atmosphere satisfy industrialists' personal expectations and perceptions of life. At the same time, there is a reluctance to show complete disdain for economic incentives and I argue that this unwillingness should develop a definite spatial pattern whereby relative location to large urban centers becomes the motivating influence for industrial location. This can be measured by use of the potential model. High potential values reflect good locations, which in turn should demonstrate relatively higher levels of recent industrial growth.

CHAPTER THREE

THE STUDY METHOD

Industrial growth is dependent upon a number of factors, to include site, situational, and behavioral characteristics. Recent statements by other researchers regarding changes in the importance of these three characteristics to entrepreneurs have served as an impetus for this study. The following assertions are of particular interest: (1) since the 1950's there has been a "trend" involving the decentralization of industry from highly urban to more rural settings;[1] and, (2) despite this trend, industrial developers seem to prefer locations within comparatively easy access to large urban concentrations.[2] This study hypothesizes that industrial growth in small cities is related to a fortuitous location relative to larger urban centers. Chapter Three is a discussion of how the sample of "small" cities and the larger urban centers were selected and how the research area was bounded. Also included in this chapter is a description of the analytical techniques used to test the hypothesis.

Selection of Sample Cities and Study Area

Small Cities

A lower limit of 25,000 persons was set for the sample of smaller cities for two reasons: (1) industrial data for cities cannot be obtained from secondary sources (census publications) for smaller units;[3] and (2)

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[1] Harren, Claude C., "Rural Industrial Growth in the 1960's," American Journal of Agriculture Economics (August, 1970).

[2] Dorf, R. An Analysis of Manufacturing Location Factors ... (An unpublished dissertation, Dept. of Economics, Kansas State University, 1976).

[3] Because of the disclosure rule, industrial data is more often than not missing for communities under the 25,000 population level.

cities must have attained a minimum size in order to support threshold requirements for a minimal level of services demanded by industry. Although there is no empirical evidence for this number, it would at least seem a reasonable assertion that a city of 25,000 people would have some variety in its service base.

An upper limit was set at 250,000 persons for one reason; once a city reaches a minimum size, the circular and cumulative growth process, as suggested by Allan Pred[4] takes effect. Wilbur Thompson has noted that "a growth mechanism, similar to a ratchet, comes into being, locking in past growth, and preventing contraction."[5] The most widely accepted population, after which attained contraction becomes unlikely, is 250,000.[6] It follows, then, that a city larger than 250,000 would not be solely dependent on relative location to insure industrial growth.

Study Area

The study area was selected on the basis of internal homogeneity and sample size. Inherent in the test hypothesis is the concept of accessibility and in this study accessibility is measured with the potential model. In the potential model, accessibility is in part a function of a distance factor, and since the effect of distance on interaction is affected by physiography, a certain amount of internal physical homogeneity is desirable.

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[4] Pred, A. The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800-1914: Interpretive and Theoretical Essays (MIT Press, Cambridge, Mass., 1966).

[5] Thompson, W. "Urban Economic Growth and Development in a National System of Cities," in The Study of Urbanization (ed. P.M. Hauser & L.F. Schnore, New York, Wiley), pg. 454.

[6] Yeates, M. & B. Garner The North American City, (N.Y., Harper & Row, 1976).

Regression analysis will be used to test the association between industrial growth and relative location. Regression requires a minimum of thirty sample units to be of any statistical worth; therefore, the sample area must have at least thirty small cities within its boundaries.

The West North Central Region of the United States, including Kansas, Missouri, Nebraska, Iowa, South Dakota, and Southern Minnesota, satisfy these requirements. With the exception of Southern Missouri, these states are in the Interior Plains physiographic division, and as such, have no major physical barriers to accessibility. In addition, there are thirty-five samples in the small city category (Appendix I)(Figure 3.1). North Dakota and Northern Minnesota were excluded from the study because forestry and mining play a large part in their economy. Because forestry and mining industries are largely affected by site factors, the northern most part of the West North Central Region was excluded from this study.

Dominant Cities

The dominant cities or large urban concentrations include every place within the study area having a population exceeding 250,000. Dominant cities just outside the study area boundaries also influence industrial growth inside the region. In order to account for the external influence, the following method for selecting dominant cities outside the study area was used: for each smaller city, the five nearest urban centers were determined irrespective of the study area boundaries; all of those cities were included in the analysis. Figure 3.1 shows the study area, complete with dominant and small city locations. See Appendix I for a complete listing, by state, of small and dominant cities.

FIGURE 3.1

STUDY AREA AND SAMPLE CITIES

---- STUDY AREA

• SMALL CITIES

o DOMINANT CENTER

SCALE

1" REPRESENTS 194 MILES

The Potential Model

The Model Defined

Potential, according to Harris, is "an abstract index of the intensity of possible contacts,"[7]-- an aggregate measure of accessibility. As such it is the ideal tool with which to measure the potential for interaction between small cities and larger cities; the greater the potential value, the greater the possible interaction, which in turn should mean more industrial growth. If industry is indeed decentralizing yet seeking locations near large urban centers, small cities with high potentials for interaction would be ideal locations for the decentralizing industries. Mathematically stated, potential is:

$$V_i = \sum_{j=1}^{n} \frac{P_j}{d_{ij}{}^{b}},$$

where V_i = Industrial potential at small city 'i'.
P_j = A measure of mass for the large center 'j'.
d_{ij}= Distance from small city 'i' to larger center 'j'.
n = Number of large centers.

Distance decay measures the declining interaction with increasing distance and is critical to the potential concept. The greater V_i, the greater the potential for interaction. In the context of this study, it is hypothesized that a small place with a large V_i will have greater industrial growth than a small place with a smaller V_i.

Foundation of the Potential Model

The earliest known explicit formulation of the concept of human inter-

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[7]Harris, Chauncy D. "The Market as a Factor in the Localization of Industry in the United States," Annals, Association of American Geographers (Vol. 44, Dec. 1954), pg. 321.

action was made by H.C. Carey in the early 1800's.[8] But the concept remained untested until 1885 when E.G. Ravenstein, from observation, suggested that migration tends to move in the direction of large population centers and that the volume of movement decreases as the distance from the center increases.[9]

With an understanding of Newtonian physics, W.J. Reilly extended this idea and proposed the "Law of Retail Gravitation."[10] According to Reilly, a city will attract retail trade from an individual in the surrounding hinterland in direct proportion to the size of the city and indirectly proportional to the distance between the individual and the attracting city. If two cities are competing for the same hinterland, the boundary where competitive influence is equal can be determined by the equation:

$$\frac{P_i}{{d_{xi}}^2} = \frac{P_j}{{d_{xj}}^2} ,$$

where P_i = the population of place 'i'.
P_j = the population of place 'j'.
d_{xi} = the distance between 'i' and the point of equal competitive influence 'x'.
d_{xj} = the distance between 'j' and the point of equal competitive influence 'x'.

In the early 1940's, G.K. Zipf[11] made Ravenstein's principle more closely resemble the original formulation in terms of Newtonian physics.[12] He argued that the demographic force (Fij) is equal to the product of a gravitational constant (G) and the populations of the two masses (Pi and Pj),

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[8] Carrothers, C.A.P. "An Historical Review of the Gravity and Potential Concepts of Human Interaction," Journal of the American Institute of Planners (1956), pg. 94-102.

[9] Ravenstein, E.G. "The Laws of Migration," J. Royal Stat. Soc. (48, 1885), pg. 167-235.

[10] Carrothers, op cit, pg. 95.

[11] Zipf, G.K. Human Behavior and the Principle of Least Effort (Mass., Addison-Wesley, 1949).

[12] Carrothers, op cit, pg. 95.

divided by the square of the distance between the two masses. Expressed algebraically:

$$Fij = G \frac{PiPj}{Dij}2$$

Also in the 1940's, J.Q. Stewart extended the Newtonian analogy to derive the concept of "population potential."[13] This may have been the first measure indicating the intensity of possible interaction. The possibility of interaction for an individual at place 'i' which is generated by area 'j' becomes greater as the size of 'j' increases and is less as the distance between 'i' and 'j' increases. The total possibility for interaction (Vi) between the individual at 'i' and all areas in the universe can be arithmetically stated in the following way:

$$V_i = \frac{P1}{d_{i1}^{\ b}} \quad \frac{P2}{d_{i2}^{\ b}} + \cdots + \frac{Pn}{d_{in}^{\ b}} = \sum_{j=1}^{n} \frac{Pj}{d_{ij}^{\ b}} \quad ,$$

It is this form of potential which is used in this thesis.

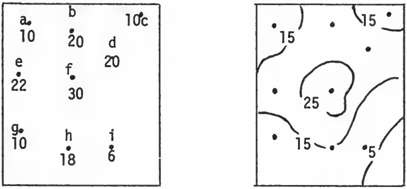
Mapping Measures of Potential

The indexes of potential accessibility or interaction can easily be mapped. The process is very similar to topographic contour mapping, the difference being that topographic maps record lines of equal altitude on the landscape and potential surfaces record lines of equal potential. In a hypothetical study area, the total potential, calculated from the equation $V_i = \ P_j/d_{ij}^{\ b}$, for a series of places is plotted on a map (see Figure 3.2A). Interpolation, in the manner common to contour mapping, between points yields lines of equal potential (isopotential lines) at desired intervals (Figure 3.2B). From maps of this nature, areas of varying potential can be

[13] Stewart, J.Q. "A Measure of the Influence of Population at Distance," Sociometry (5:63-71, 1942).

Figure 3.2

MAPPING POTENTIAL



A B

easily visualized. Appropriately, the isopotential lines of highest value encircle the places of greatest potential accessibility or possible interaction.

Applications to Location Theory

The concept of potential or accessibility was introduced to location theory by Chauncy Harris.[14] Harris used the concept to calculate market potential (P) which he defined as the sum (Σ) of all markets accessible to a point (M) divided by their distances (d) to that point:

$$P = \sum\left(\frac{M}{d}\right).$$

Using this model, Harris developed a map of market potential (Figure 3.3); a summary map measuring accessibility to consumers, for the United States. From this he concluded:

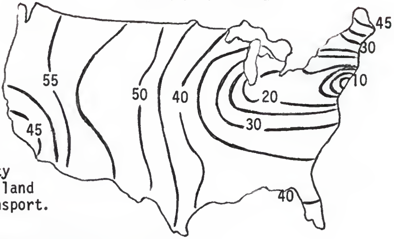
> "A large and very significant fraction of manufacturing in the United States is not tied to local raw materials, local markets, or current regional differences in power or labor costs. This segment, typified by the automobile

[14] Harris.

and agricultural machinery industries, appears to be concentrated in areas having maximum accessibility to national or regional markets for such products."[15]

FIGURE 3.3

MARKET POTENTIAL



Percent below N.Y. City by combined land and sea transport.

Source: Harris, 1954, pg. 324, fig. 6.

In his paper, Harris made two important modifications to the interactance model:[16] (1) he used retail sales in the numerator, and (2) freight costs as a surrogate of distance. Harris also developed a model based on the argument that manufacturers will locate at the point which minimizes transportation costs.

Two years later, Edgar S. Dunn combined Harris' market potential and transportation cost models to develop what he termed an "Index of Location."[17] Dunn argued that market potential could only be used when analyzing firms that were not transport oriented, and that the transport cost model could only be used for those firms that are transport-market oriented. Dunn's solution was to take the product of these two measures, any disadvantage in

[15] Ibid., pg. 316.

[16] Ray, D.M. Market Potential and Economic Shadow (Chicago: University of Chicago, 1965), pg. 26.

[17] Dunn, Edgar S. "The Market Potential Concept and the Analysis of Location," Papers and Proceedings of the Regional Science Association (Vol. 2, 1956), pg. 183-195.

either index, according to Dunn, being exactly offset by the advantage in the other. (For a more detailed discussion, see Dunn's paper, cited above).

More recently, D. Michael Ray has used the interactance model to develop a regional industrial location model for southern Ontario.[18] Ray supports the use of potential models in industrial location analysis because (1) the concept has empirical support as well as its theoretical foundations in both the social and physical sciences; and (2) potential assumes that interaction declines with distance. However, he questions the worth of the potential transport-cost model because (1) it assumes that manufacturers serve entire market areas and can absorb the cost of doing so; and (2) there is some difficulty in defining market areas, ie., extension of the market area has an increasing effect on potential transport costs as opposed to the decreasing effect it has on market potential.

Application of the Model

Over the past twenty-five years, the ability of the potential model to increase our understanding of the geographic patterns of manufacturing has been a source of keen interest. As a result, this concept has become well established in location analysis.[19] This study will utilize the previously mentioned model, $V_i = \sum_{j=1}^{n} P_j/d_{ij}^b$, to evaluate a city's ability to attract industry based on its potential index (V_i). This section will briefly outline the computational procedures through which each component in the equation was determined.

[18] Ray, op cit.
[19] Smith, David M. Industrial Location (New York, John Wiley & Sons, Inc., 1971), pg. 98.

Distance (d_{ij}^b)

Distance is calculated as the shortest map distance, in miles, between any two cities. According to Harris, "because the United States is covered by a dense network of highways and railroads, the shortest distances on a map are proportional to actual route miles."[20] Distance as a function of cost, also suggested by Harris,[21] was not used because it has not proven superior to miles when measuring distance decay.[22]

Distance was exponentiated by the distance decay power $b = 1$. A considerable amount of debate has surrounded exponent choice and researchers have varied it from one to three. In locational analysis, an exponent of one seems to be the most agreed upon.[23] To insure that one is representative of distance decay, the computations in this thesis will be made with $b = 2$ also (see Chapter Four). Peter Taylor[24] has suggested a method with which the exponent can be calibrated, but it would require more time than is justified in this study.

Measures of Mass (P_j)

As noted earlier, Chauncy Harris considered retail sales to be the single most valuable measure of market for the industrialist. Others have argued that wholesale trade is superior.[25] Because this study is testing the association between industrial growth in smaller cities and relative location to larger urban centers, and not just market potential, several

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[20] Harris, op cit, pg. 323.

[21] Ibid.

[22] Ray, op cit, pg. 74.

[23] See Comments by Harris, pg. 326 and by Ray, pg. 74.

[24] Taylor, Peter J. Distance Decay in Spatial Interactions, (University of East Anglia, Norwich, 1967).

[25] Kerr, Donald and Jacob Spelt "Some Aspects of Industrial Location in Southern Ontario," Canadian Geographer, (No. 15, 1960) pg. 12-25.

measures of mass were selected. The measures of mass are indicators of the attracting force and ability of larger cities to influence industrial growth and clearly no single measure can demonstrate this. According to central place theory, the larger the place, the greater its area of influence. Therefore, population should be an important measure and 1965 SMSA population was selected. Retail sales was selected as a second measure of mass because it is an indicator of market place and service base, both of which are important to the industrialist. Wholesale trade was not selected because there is a considerable volume of trade between wholesalers thus overstating the value of trade moving out of the wholesale category.[26]

Because the interest is in measuring industrial growth in small cities, two measures of industrial attraction were selected from the urban centers: payroll in selected assembling and fabricating industries and value added by manufacturing. Payroll was selected as a surrogate for industrial wages and value added as a measure of industrial magnitude. The greater these numbers, the greater the industrial shadow or area of influence and the greater the potential for industrial spinoffs and establishment of branch plants. These variables are listed in Appendix II.

The Computations

For this research, then, potential is equal to the summation of large centers' measure of mass divided by the distance from that point to a small city.* Mathematically:

$$V_i = \sum_{j=1}^{35} \frac{P_j}{d_{ij}^{\,b}} \quad ,$$

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[26]Ray, op cit, pg. 78.

*These computations were made with Kansas State University's computer and the Fortran design statement is given in Appendix III.

where V_i = industrial growth potential for city 'i'.
P_j = large center population, retail sales, payroll in selected assembling and fabrication industries, or value added by manufacturing.
d_{ij} = the nearest map distance between each small city (i) and each larger center (j).
b = distance decay exponent of one.

Measures of Association

In order to ascertain whether or not the indexes of industrial potential are of any value as predictors of industrial growth, empirical tests must be made. Conveniently, regression and partial correlation analysis are statistical techniques designed specifically to test associations between interval scaled sets of data as used in this study.

Simple Regression

Simple regression is a technique often used by geographers.[27] It will be used in this study to determine which of the potential variables best describes industrial growth in smaller cities. Industrial growth variables are plotted on the Y-axis and, in turn, each of the potential indexes are plotted on the X-axis. From these plots, a regression line is computed and the association between the potential indexes and industrial growth variables determined.

The regression line is characterized by two parameters 'a' and 'b'; 'a' represents the point where the least-squares line crosses the Y-axis, or where X equals zero. The regression coefficient or 'b' is the slope of the line. Thus, the relationship between X and Y is represented by the regression line and can be expressed in the following manner:

$$Y = a + bX$$

[27] Yeates, Maurice An Introduction to Quantitative Analysis in Human Geography (New York, McGraw-Hill Book Company, 1976), pg. 67.

If the association is linear and one knows 'a' and 'b', knowledge about X (industrial growth potential) can help to predict Y (small city industrial growth). It must be emphasized, however, that this relationship does not measure causality, only that there seems to be a relationship between the two variable sets.[28] (The computing formulas for 'a' and 'b' are given in Appendix IV).

Karl Pearson suggested a further use of least-squares which he termed correlation analysis. The correlation coefficient (r), presented by Pearson, measures the amount of point spread about the linear least-squares line. The Pearsonian product moment correlation coefficient is defined mathematically as:

$$r = \frac{\sum_{i=1}^{n} (X_i - \bar{X})\,(Y_i - \bar{Y})}{N s_x s_y},$$

where X_i = the observed independent variable.
$\bar{X}$ = the mean of the dependent variables.
Y_i = the observed dependent variable.
$\bar{Y}$ = the mean of the dependent variables.
S_x = standard deviation of x.
S_y = standard deviation of y.

The correlation coefficient has an upper limit of one (or minus one) which means that all the points plotted on the X-Y coordinate system lie exactly on the least-squares line. If 'r' equals zero, the points are randomly scattered and there is no apparent correlation (r is equal to the explained sums of squares divided by the total sums of squares). Further, the square of the correlation coefficient can be interpreted as the proportion of the total variation in the dependent variables explained by the independent variable. If the correlation coefficient (r) is small, close to zero, then

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[28]For more detailed discussion of regression, see Social Statistics by Hubert M. Blalock, Jr. (New York, McGraw-Hill Book Company, 1972).

the obvious conclusion would be that there is no association between the dependent and independent variables. But the results depend on sample size and for this reason it is possible, and sometimes advisable, to test the significance of 'r' through the use of an F-test. The formula for this test is given in Appendix VII.

Multiple Regression

In multiple regression, we consider the relationship between a dependent variable and two or more independent variables. Similar to the least-squares equation, $Y = a+bX$, the multiple regression equation takes the form:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n.$$

As in simple regression, there is a correlation coefficient, except that in multiple regression it is termed multiple R and it demonstrates the strength and direction of the relationship between the dependent variable and all of the independent variables. When squared, R becomes the coefficient of determination (R^2) and it is similar to r^2 in that it represents the proportion of variation explained jointly by the independent variables.

Partial Correlation Analysis

The regression model can be further modified to show the relationship between a dependent variable and an independent variable while holding the effect of one or more independent variables constant. The procedure is called partial correlation analysis. If the effect of only one variable is held constant, it is called a first order partial; if the effects of two variables are held constant, it is called a second order partial, etc... The formula for a first order partial is given in Appendix IV. As with

simple regression, the results of multiple regression may be misleading with a small R value which is still significant. To test the significance of the association, a formula is provided in Appendix IV.

Application

In this paper simple regression, multiple regression and partial correlation analysis are used to test the association between industrial growth in small cities and relative location. Potential, the concept described in the first half of this chapter, is used to obtain measures of relative location. The industrial growth variables for small cities are: (1) change in the number of employees from 1963 to 1972 (also calculated on a per capita basis), and (2) change in the number of manufacturing places from 1963 to 1972. This data is listed in Appendix V.

Employment is the classical measure of industrial change and it was selected for two reasons. First, a plant that is expanding must decide whether to expand in place or elsewhere, a locational decision is made and this variable measures that decision. Secondly, a community that attracts a firm that employs 5,000 persons experiences more growth than the community that attracts five one-hundred employment firms. Again, this type of growth is measured by the "change in employment" variable.

However, the fact that a community attracts five firms, despite their smaller size, indicates the community's location was evaluated and found optimum more times than the community attracting only one large firm. For this reason, the "change in number of places" variable is also used to indicate industrial growth.

The Computations

The following tests of association will be made[29] using the simple regression formula, Y = a + bX. Each of the potential measures, population, retail sales, selected assembling and fabricating industry payroll, and value added by manufacturing, are regressed against the industrial growth measures (which in every case are the dependent (Y) variables). Also a multiple regression run is made to determine the degree to which all the potential measures jointly explain industrial growth in small cities.

Also, because industrial growth is explained by site as well as situational characteristics, three site characteristics for small cities were selected, combined with the measures of industrial potential and will be included in a multiple regression equation (this is further discussed in Chapter Four). The site measures include population, retail sales, and value added by manufacturing. Finally, third order partial correlations are run holding the effects of the site variables constant. Results and analysis of each of these tests are given in Chapter Four.

Summary

This chapter provides a general understanding of the computational procedures with which this research is undertaken. The potential model provides quantitative measures of relative location or industrial potential for smaller cities. The potential values are obtained by dividing each of the four measures of mass (population, retail sales, payroll in selected assembling industries, and value added by manufacturing) by the distance from each small city to each large center. These industrial

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[29]The tests of association were made through use of standard computing routines found in the following text: Statistical Package for the Social Sciences by N. Nie and others, McGraw Hill Book Company, New York, 1975.

potential indexes are used to develop contour maps for use in the analysis of location. Regression and partial correlation analyses are used to determine the strength of the relationship between industrial growth in small cities and location relative to large urban concentrations. Chapter Four will provide the results of the techniques described in this chapter as well as an analysis of those results.

CHAPTER FOUR

RESULTS AND ANALYSIS

This chapter is divided into two sections. The first describes and analyzes potential maps defined by industrial growth indexes. The second section includes the results and analysis of correlation tests between potential indexes and industrial growth variables. The first section should be particularly interesting to industrialists or entrepreneurs seeking locations which optimize relative location, based on access to large urban centers; ie., the decentralizing industrialist. The section devoted to the interpretation of the correlation analyses should be more important to the organizations competing for those decentralizing industries (Chambers of Commerce, for example). If these organizations would be willing to accept the original hypothesis that industry is decentralizing yet seeking locations with "good" access to large urban centers, the isopotential maps would suffice as the basis for their industrial prospecting strategies. However, since most are unwilling to risk the economic fate of their communities on an unproven hypothesis, the second section is offered as an empirical test of how industries in small cities, over the ten-year period of 1963 to 1972, behaved relative to the potential indexes from which the isopotential maps are determined.

Analysis of the Industrial Growth Isopotential Maps

To develop the industrial growth isopotential maps, the previously discussed model, $V_i = \sum_{j=1}^{n} (P_j/d_{ij}^b)$, was applied. For each map, P_j changed while d_{ij}^b remained fixed. In the first map, population was used; in the second, retail sales; and the third used value added by manufacturing;

while in the fourth, P_j was payroll in selected fabricating industries. Industrial growth potential in small cities is a reflection of these four P_j characteristics obtained from the large urban concentrations. The denominator, d_{ij} , was calculated as the shortest map distance, in miles, between each small city (i) and each large city (j). The exponent, b, was set at one. This decision was based on two factors: (1) a review of the literature and (2) empirical evidence from this study. For each P_j, the equations were calculated with both b = 1 and b = 2. The results were regressed against the industrial change variables, "change in the number of manufacturing places", and "change in the number of manufacturing employees," and the exponent b = 1 provided the equation having the strongest association with the dependent variables.

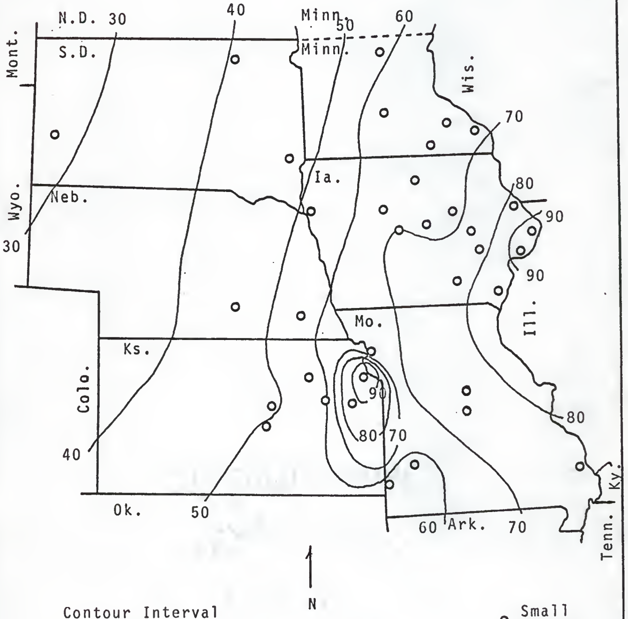
Having obtained each component of the potential model, the equations were solved and potential indexes assigned to each small city. Based on these indexes, isopotential maps were drawn, in a manner very similar to contour maps, with the areas encircled with isopotential lines of high value indicating areas of greatest potential for industrial growth (Figure 4.1 - 4.4).

Results

The isopotential lines gradually decrease in value from east to west for all four maps, indicating that the cities in the eastern part of the region are the most accessible, ie., have the best locations relative to large economic and population agglomerations. The high values in the eastern part of the potential surface are definitely affected by the very large industrial and population mass of Chicago. In addition, these cities are near Des Moines, which is not exceptionally large when compared with a

INDUSTRIAL GROWTH POTENTIAL
BASED ON POPULATION

FIGURE 4.1

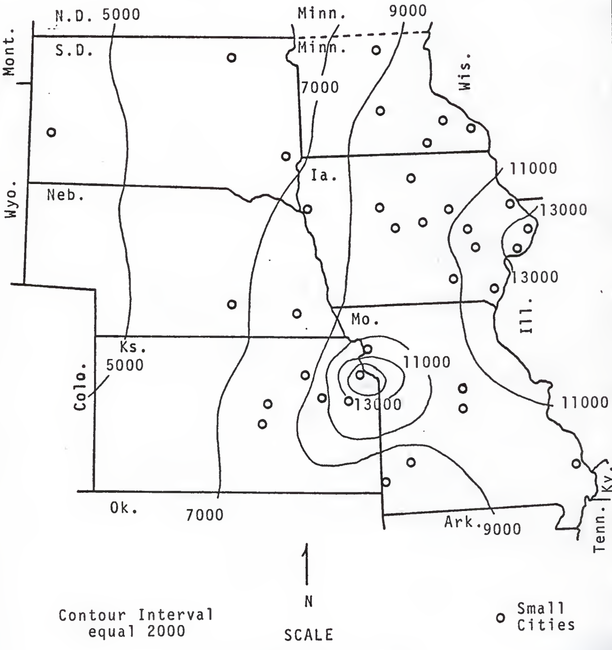


Contour Interval equal 10

SCALE
1" REPRESENTS 138 MILES

o Small Cities

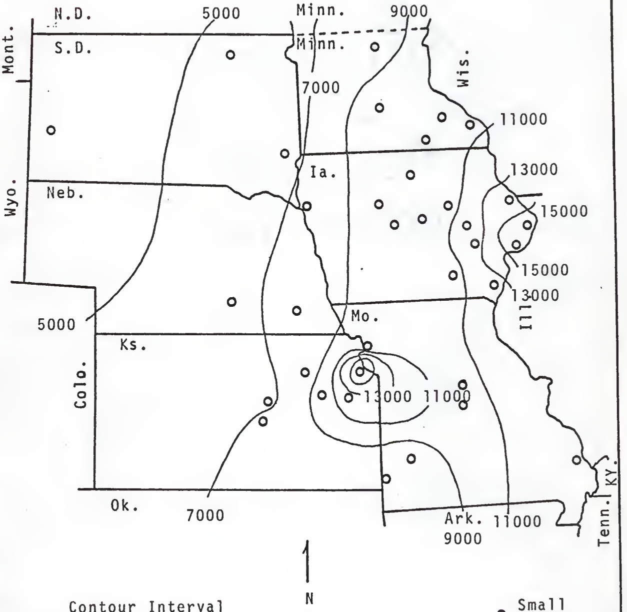
INDUSTRIAL GROWTH POTENTIAL
BASED ON RETAIL SALES
FIGURE 4.2



1" REPRESENTS 138 MILES

INDUSTRIAL GROWTH POTENTIAL
BASED ON VALUE ADDED BY MANUFACTURING

FIGURE 4.3



Contour Interval equal 2000

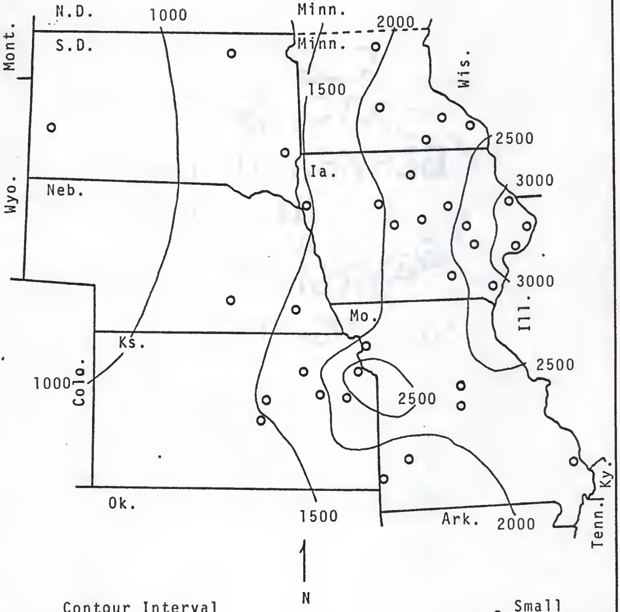
SCALE

1" REPRESENTS 138 MILES

Small Cities

INDUSTRIAL GROWTH POTENTIAL
BASED ON PAYROLL

FIGURE 4.4



Contour Interval equal 500

SCALE

Small Cities

1" REPRESENTS 138 MILES

metropolis like Chicago, but its short distance from each of the eastern Iowa cities inflates potential values. Also Minneapolis/St. Paul is to the north, Kansas City to the southwest, St. Louis to the south, etc. For the most part, the cities on the northeast portion of the potential surface are the most centrally located with respect to the large urban concentrations and, therefore, have the highest industrial potential indexes.

In general, four different P_j values (population, retail sales, value added by manufacturing, and industrial payroll) yield similar potential surfaces, decreasing in value from east to west. However, the area around Leavenworth, Kansas is also encircled with isopotential lines of high value. These high value isopotential lines can also be logically explained. Kansas City is very large, very near, and exerts much influence, increasing the potential values of nearby cities. As with eastern Iowa, this area is also centrally located; St. Louis is near to the east, Omaha/Council Bluffs not too distant to the north and Wichita not far south.

With only Denver to the west, Tulsa and Oklahoma City to the far south, and no major cities to the north, it is not surprising that the northwest part of the potential surface is bounded by isopotential lines of the lowest value.

Analysis

If the hypothesis is correct and industries are decentralizing from large urban centers to more rural settings, yet maintaining accessibility to those large centers, then groups of cities can be determined, based on ranges of potential indexes, with the most accessible places in Group "A" and the least accessible in Group "F". The groups are listed in Table 4.1. Because of their similarity, ranges are given for only one variable, ie., retail sales.

Based on this grouping, one would suspect that decentralizing industries would find Group "A" to be the most attractive places in which to locate and Group "F" to be the least attractive. From the potential maps, entrepreneurs can determine how much accessibility they are willing to sacrifice for increasingly more rural settings. In addition, prospecting organizations can determine how well situated they are and decide on the need, extent, and aggressiveness of their industrial prospecting campaigns. For example, less favorably located cities might have to mount more impressive campaigns to offset their poor locations.

TABLE 4.1

CITY ACCESSIBILITY GROUPINGS IN DECREASING ORDER

GROUP	PLACES	RANGES OF POTENTIAL INDEXES (RETAIL SALES)
A	Clinton,Ia. Davenport, Ia. Leavenworth, Ks.	13,000 or higher
B	Lawrence, Ks. Cedar Rapids, Ia. Iowa City, Ia. Burlington, Ia. Dubuque, Ia. St. Joseph, Mo.	11,000 - 12,999
C	Ft. Dodge, Ia. Mason City, Ia. Mankato, Minn. Topeka, Ks. Austin, Minn. Winona, Minn. Marshalltown, Ia. Waterloo, Ia. Rochester, Minn. Cape Girardeau, Mo. Jefferson City, Mo. Columbia, Mo. Ottuma, Ia. Cedar Rapids, Ia. Ames, Ia.	9,000 - 10,999
D	Salina, Ks. Sioux City, Ia. Hutchinson, Ks. Lincoln, Nb. Manhattan, Ks. St. Cloud, Minn.	7,000 - 8,999
E	Aberdeen, S.D. Sioux Falls, S.D. Grand Island, Nb.	5,000 - 6,999
F	Rapid City, S.D.	4,999 or less

But the question still arises, "Is the hypothesis correct and are industries decentralizing to the suggested locations?" Several empirical tests have been made to discover if industrial growth, for the period of 1963 to 1972, did indeed correspond with the areas suggested by the iso-potential maps, the results of which are included in the next section.

Correlation and Regression Analysis

First, simple regression tests are made to find out if the industrial location potential findings are associated with industrial growth. Next, a multiple regression test is conducted in which all the potential indexes are regressed with the industrial growth variables to determine their cumulative association. Included in this section is a regression analysis in which site variables are correlated with industrial growth variables in order to compare the explaining power of site versus situation. This process includes forcing the site variables into the regression equation first, followed by the situational potential indexes, to determine what, if any, additional explanation situation has over site. The final segment involves tests of partial correlation in which the site variables are held constant while each of the potential indexes are regressed against the dependent industrial growth variables.

Simple Regression

In the first part of this chapter, potential indexes were used to develop maps for use in the analysis of industrial location problems. For many, questions would arise concerning the relative worth of these maps. For this reason, simple regression tests have been made correlating each of the potential indexes, based on payroll in selected fabricating industries,

population, retail sales, and value added by manufacturing, against two industrial growth variables, "change in the number of manufacturing places" and "change in the number of manufacturing employees." The results are listed in Table 4.2.

TABLE 4.2

THE ASSOCIATION BETWEEN MANUFACTURING GROWTH AND INDUSTRIAL LOCATION POTENTIAL

Independent Variable	r	r^2	F
Simple regression dependent upon: Change in # of Mfg. Places			
Payroll	.285	.081	2.91
Population	.201	.041	1.40
Retail Sales	.194	.038	1.30
Value Added by Mfg.	.250	.062	2.20
Simple regression dependent upon: Change in # of Mfg. Employees			
Payroll	.006	Tolerance level was insufficient for calculation	
Population	.013		
Retail Sales	.020	.000	.013
Value Added by Mfg.	.018	.000	.011

As can be seen from the very low r values, the industrial location potential indexes contribute very little to explaining industrial growth in small cities. In order for r to be significant at the .05 level, F would need to be at least 4.12; the highest F statistic in these tests is 2.91. Based on these results, one would have to assert that relative location to large urban concentrations plays a very minor role in explaining industrial growth in non-metropolitan cities. At the very most, in the case of 'payroll

in selected fabricating industries' explaining 'change in the number of manufacturing places,' relative location is explaining only eight percent of the variation in the dependent variable, and at an insignificant level.

Multiple Regression

Because relative location can be measured by several indexes, the four measures of potential (population, retail sales, payroll ..., and value added ...) are combined to form a cumulative measure through use of multiple regression. The dependent variables remained the same as in the simple regression analysis (ie., "change in the number of manufacturing places" and "change in the number of manufacturing employees") and the results are listed in Table 4.3. Once again, the R values are low, indicating that there is little, if any, relationship between relative location and industrial growth. This further demonstrates that there seems to be little, if any, relationship between industrial growth in small cities and favorable locations with respect to large centers as measured by the potential model.

TABLE 4.3

THE ASSOCIATION BETWEEN MANUFACTURING GROWTH AND CUMULATIVE MEASURES OF INDUSTRIAL LOCATION POTENTIAL

Dependent Variable	R	R^2	F	DF
Places	.379	.144	1.26	4
Employees	.151	.023	.242	3

Note: DF = Degrees of freedom.

Because the measures of situation (relative location) contribute little or no explanation to the industrial growth variables, a multiple regression run was made in which site variables (population, retail sales, and value added by manufacturing) for small cities were forced into the equation, ahead of the situational variables in order to determine: (1) if site explains industrial growth better than situation; and (2) how much additional explanation does situation contribute beyond that of site. The results of this analysis are listed in Table 4.4 on the following page.

As shown in Table 4.4, site variables do not contribute any dramatic explaining power about industrial growth. "Site" explains only nine percent of the variation in manufacturing places and twenty-five percent of the variation in manufacturing employees. What is more important to this research is that the situational variables more than double the explaining power about "change in the number of manufacturing places," and increase the explanatory power about "change in the number of manufacturing employees" by over seventeen percent. This indicated that for industrial growth to occur in nonmetropolitan cities, situation is as important as site. However, neither site nor situation or a combination of site and situation explain a majority of the variation in industrial growth.

Partial Correlation Analysis

Partial correlation analysis is used to control for the effects of site. Each industrial location index is correlated with the industrial growth variables while holding the effects of site constant. The results of this analysis are listed in Table 4.5. It is obvious from this table that when controlling for site, no single measure of situation contributes very much toward explaining variation in industrial growth on the landscape.

TABLE 4.4

COMPARISON OF REGRESSION RESULTS FOR
SITE AND SITUATION VARIABLES

	Independent Variables	R	R^2
Multiple regression with Change in # of Mfg. Places as dep. variable			
	Population	.18049	.03258
SITE	Retail Sales	.18125	.03285
	Value Added by Mfg.	.30148	.09252
- - - - - - - - - -			
	Payroll	.36470	.13301
SITUATION	Value Added by Mfg.	.37419	.14002
	Population	.45065	.20309
	Retail Sales	.45108	.20347
Multiple regression with Change in # of Mfg. Employ. as dep. variable			
	Population	.44244	.19575
SITE	Retail Sales	.45005	.20255
	Value Added by Mfg.	.50196	.25197
- - - - - - - - - -			
	Payroll	.51569	.26594
SITUATION	Value Added by Mfg.	.54797	.30027
	Population	.57198	.32716
	Retail Sales	.57198	.32716

NOTE: Those variables below the broken lines --- are based on potential indexes.

TABLE 4.5

SIMPLE AND PARTIAL CORRELATION RESULTS

Independent Variables	Simple Correlation r	Partial Correlation r
Comparison based on: Change in # of Mfg. Places		
Payroll	.285	.211
Population	.201	.134
Retail Sales	.194	.141
Value Added By Mfg.	.205	.185
Comparison based on: Change in # of Mfg. Employees		
Payroll	.006	.094
Population	.013	.137
Retail Sales	.020	.062
Value Added By Mfg.	.018	.084

Summary and Conclusions

This chapter illustrated four industrial location potential surfaces based on population, retail sales, value added by manufacturing, and payroll in selected fabricating industries. If industrial locating entrepreneurs are willing to accept the hypothesis that industry is decentralizing from metropolitan centers but seeking locations with good relative accessibility to those centers, then these maps can be used to select areas with high accessibility. Also, industrial prospecting organizations can use these maps to evaluate the relative "goodness" of their locations as a basis for their prospecting strategies.

In the second part of Chapter Four, the measures of industrial potential were regressed against industrial growth variables taken for the period from 1963 to 1972. Three noteworthy conclusions can be drawn from these results: first, it was found that none of the potential surfaces significantly explain industrial growth from 1963 to 1972. Second, when the potential indexes were combined in a cumulative multiple regression analysis, they did not significantly explain the variation in the industrial growth variables, "change in the number of manufacturing employees" and "change in the number of manufacturing places." Finally, it was found that situation explains as much of the variation in industrial growth as site variables but both leave a large amount of the variation unaccounted for. These results lead me to conclude that industries locating in smaller cities in the Plain States behave in a footloose manner.

CHAPTER FIVE

CONCLUSION

Summary

The purpose of this study has been to determine the degree to which industrial growth in nonmetropolitan cities is associated with location relative to large urban population and activity agglomerations. Potential was used to measure a small city's accessibility to large urban centers; it weighs the importance of a large center, to industrial growth in small cities, by its distance to the small cities.

This study examines how the accessibility to four mass surrogates (population, retail sales, value added by manufacturing, and payroll in selected fabricative industries) effects industrial growth in smaller cities. Retail sales is an effective measure of market place and has been used widely in similar studies. Population was selected to measure the size of the large cities and the industry variables were selected as measures of industrial mass. The purpose was to select a limited number of variables to best represent the effect large urban masses have on industrial growth in smaller cities.

In 1954, Chauncy D. Harris[1] suggested the use of retail sales as the best single measure of market and it has since become the most accepted indicator. In that same paper, Harris suggested that transportation cost was the most effective measure of distance; however, cost does not provide a more accurate measure of distance-decay than distance itself.[2] Because of the importance of distance-decay to the potential model, there has been

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[1] Harris.

[2] Ray, pg. 144.

much discussion on the distance-decay exponent or the decreasing rate of accessibility with increasing distance. Many researchers have argued that decay is curvilinear and as a result, it is the function of some exponent. However, there is no conclusive evidence of this and when exponents of one and two were tested in this study, one provided the equation with the strongest correlation to industrial growth. The final potential model was defined mathematically as:

$$V_i = \frac{P_j}{d_{ij}^{\,b}} \quad ,$$

where V_i = industrial potential.
P_j = retail sales, population, value added by manufacturing, or payroll in selected fabricating industries.
d_{ij} = distance between small city (i) and larger city (j)
b = distance decay exponent of one.

From this model four maps of industrial potential were developed (Figure 4.1 - 4.4, Chapter Four) all of which indicate that eastern Iowa and the general area around Leavenworth, Kansas are the most accessible within the study area and should therefore experience the greatest industrial growth.

In order to test these maps, two industrial growth variables (dependent variables), "change in the number of manufacturing places" and "change in the number of manufacturing employees," were selected for smaller cities in the time period from 1963 to 1972. Each of the potential indexes were regressed against the industrial growth variables and in each case, explain little of the variation in the dependent variables. "Payroll in selected fabricating industries" explained the most variation in industrial growth (eight percent). From these results, I have to conclude that no single measure of relative location can adequately describe industrial growth in the prairie states' small cities.

Based on the premise that no single variable is an adequate measure of relative location, the four potential indexes were combined in a multiple regression equation and again regressed against the industrial growth variables. Once again relative location failed to explain industrial growth as measured by change in the number of manufacturing places or employees.

Because only a small amount of the variation in the dependent variables is explained by situation, an additional regression analysis was made in which three site (smaller city) variables, population, retail sales, and value added by manufacturing, were forced in the regression analysis ahead of the situational variables. From this analysis, two notable conclusions can be drawn: (1) site seems to play only a minor role in industrial growth; and (2) situation adds significantly to the explanation. Unfortunately, even when site and situation are combined, over sixty-seven percent of the variation in industrial growth still remains to be explained. These results lead me to conclude that industry in nonmetropolitan cities seems to behave in a footloose manner or responds to variables other than those I have selected.

Comparison With Previous Studies

Since the 1950's, potential and gravity models have found increasing use in social science research. In his memorable paper, "The Market as a Factor in the Localization of Industry in the United States," Chauncy Harris introduced the concept to location analysis. Since then, two noted scholars, Edward Dunn (economist) and Michael Ray (geographer), have used the model successfully in industrial location analysis.

In a manner similar to that employed inthis study, Ray used potential to explain the number of manufacturing workers and plants in Southern Ontario counties. He, too, used correlation analysis to test his results and his correlation coefficients were .82 and .87 respectively. The correlation coefficients, based on retail sales, explaining "change in the number of manufacturing workers" and "change in the number of manufacturing plants" in central United States' small cities, from this study, were .020 and .194 respectively. By comparing these two studies, the inference can be made that potential effectively describes total existing industry but is an inadequate technique through which to measure industrial growth.

Implications for Future Studies

Based on the results of this study, it would seem that potential is an inadequate tool with which to measure industrial growth. There appears to be little association between relative location and industrial growth. However, these results may be misleading. For example, future studies should establish a floor on industry size; because of the obvious risks in starting a new business, small plant owners possibly perceive their hometown as the safest place in which to begin (or in terms of Pred's Behavioral Matrix, they have the least knowledge and ability to use that knowledge when making a locational decision). These decisions could obviously upset results.

In addition, the county is probably a better unit of measurement. Many industries may have located on the outskirts of the "well situated" small towns and were not recorded because of the data unit. Also, any industry once in the downtown area of small cities, may have opted for a peripheral location in which to expand. By using the city as the unit of measurement, an important amount of industry, located outside of city limits, may have

been excluded from this study. Until these changes are made and the hypothesis retested, I will be reluctant to totally reject the original hypothesis that industrial location is decentralizing from larger urban centers yet seeking locations of high accessibility. Granted that there may be flaws in the study design, within the framework of the study I cannot accept the original hypothesis. Therefore, I can only conclude that industrial growth, in cities between 25,000 and 250,000 population, is not strongly associated with location relative to large urban centers in Kansas, Nebraska, Iowa, South Dakota, and southern Minnesota.

Because the results of this study are not in agreement with those of other studies, several questions arise. For example, were there flaws in previous study designs? An additional question occurs around the use of the potential model; if similar studies yield such different results, is it actually an adequate or even dependable tool with which to measure relative location?

There is also the possibility that industry is decentralizing from large urban centers in one geographic area, for example, the industrialized north, to smaller cities with good locations relative to large urban centers, in an entirely different geographic area, the southern United States. This suggests that the study should be reapplied but in a different study area.

Finally, there is the implication that, as suggested by Allan Pred, it is behavioral characteristics that influence industrial growth. For example, an industrial entrepreneur's awareness of a place may be more important when influencing the location of an industry than distance from a large center. Although it was assumed in this study that distance serves

as a surrogate for awareness, it is not necessarily so. This indicates need for future studies testing the importance of behavioral characteristics (such as entrepreneurial awareness) to industrial growth.

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APPENDICES

APPENDIX I

LIST OF CITIES

STATE	SMALL CITIES	DOMINANT CENTERS
Kansas	Hutchinson Leavenworth Lawrence Manhattan Salina Topeka	Kansas City Wichita
Missouri	Cape Girardeau Columbia Jefferson Joplin Springfield St.Joseph	Kansas City St. Louis
Nebraska	Grand Island Lincoln	Omaha/Council Bluffs
Iowa	Ames Burlington Cedar Rapids Clinton Dubuque Fort Dodge Iowa City Marshaltown Mason City Ottumwa Sioux City Waterloo Davenport	Des Moines Omaha/Council Bluffs
South Dakota	Aberdeen Rapid City Sioux Falls	
Minnesota	Austin Mankato Rochester St. Cloud Winona	Minneapolis/St.Paul
Colorado		Denver
Oklahoma		Oklahoma City Tulsa

APPENDIX I
(Continued)

STATE	SMALL CITIES	DOMINANT CENTERS
Arkansas		Little Rock
Tennessee		Memphis Nashville
Kentucky		Louisville
Indiana		Indianapolis
Illinois		Chicago
Wisconsin		Milwaukee

APPENDIX II

MASS VARIABLES

P_j SMSA	1960 POPULATION (1000)	1963 RETAIL SALES ($1000)	1963 PAYROLL IN SELECT FABRICATING INDUSTRY ($1000)	1963 VALUE ADDED BY MANUFACTURING ($1000)
Denver	929	1,533,623	81,664	926,076
Tulsa	419	583,339	94,587	292,674
Oklahoma City	512	804,506	40,421	299,202
Little Rock	272	345,533	15,142	140,055
Memphis	675	895,083	49,586	575,265
Nashville	464	623,799	48,710	489,718
Louisville	725	977,470	112,952	1,595,638
Indianapolis	945	1,401,038	428,712	1,368,526
St. Louis	2105	2,847,475	690,112	3,119,263
Kansas City	1093	1,682,887	221,985	1,514,178
Wichita	382	521,437	219,388	480,121
Omaha/Council Vluffs	458	666,497	23,108	423,007
Des Moines	266	411,223	12,572	285,200
Chicago	6221	9,889,061	2,509,359	11,939,525
Milwaukee	1279	1,706,994	758,668	2,237,200
Minneapolis/ St. Paul	1482	2,194,393	495,721	1,956,917

Source: U.S. Bureau of Census, Census of Business: Retail Sales; Census of Manufacturers, Area Series; Census of Population: General Population Characteristics.

APPENDIX III

INDUSTRIAL GROWTH VARIABLES FOR SMALL CITIES 1963-1972

SMALL CITY	MANUFACTURING PLACES			MANUFACTURING EMPLOYEES		
	1963	1972	change 1972-1963	1963	1972	change 1972-1963
Hutchinson	71	79	8	3,176	5,100	1,924
Salina	50	62	12	1,287	1,400	113
Manhattan	21	21	0	279	300	21
Topeka	124	157	33	3,841	9,500	5,659
Lawrence	50	60	10	2,318	3,500	1,182
Leavenworth	26	29	3	1,176	1,400	224
St. Joseph	109	102	-7	10,479	9,400	-1,079
Columbia	47	54	7	1,389	2,100	711
Jefferson City	37	48	11	1,740	3,000	7,260
Springfield	157	219	62	10,270	16,300	6,030
Joplin	93	105	12	4,375	5,800	1,425
Cape Girardeau	57	66	9	2,462	3,600	1,138
Grand Island	31	40	9	822	1,800	978
Lincoln	168	182	14	9,063	11,600	2,537
Sioux City	151	123	-28	7,093	7,700	607
Davenport	141	117	-24	8,012	9,900	1,888
Clinton	47	38	-9	4,076	4,300	224
Ames	25	30	5	1,013	1,300	287
Iowa City	27	36	9	1,039	2,000	961
Dubuque	88	92	4	6,820	14,200	7,380
Mason City	45	44	-1	2,635	3,100	465
Waterloo	112	101	-11	16,640	17,100	460
Fort Dodge	63	59	-6	4,493	3,800	-693
Cedar Rapids	161	156	-5	22,899	21,900	-999
Burlington	65	57	-8	5,863	8,900	-3,037
Marshaltown	47	47	0	4,285	5,700	1,415
Ottumwa	39	37	-2	5,433	5,100	-333
Rapid City	52	50	-2	1,031	1,300	269
Sioux Falls	68	82	14	5,501	6,600	1,099
Aberdeen	23	29	6	667	1,300	633
St. Cloud	74	68	-6	2,423	3,800	1,377
Winona	79	75	-4	4,402	5,000	598
Rochester	41	50	9	4,559	6,300	1,741
Austin	20	20	0	5,054	5,054	0
Mankato	45	53	8	2,149	3,300	1,151

Source: U.S. Bureau of Census, <u>Census of Manufacturers, Area Series</u>.

APPENDIX IV

LIST OF SITE VARIABLES

SMALL CITIES	Population (100)	Retail Sales ($1,000)	Value Added by Mfg ($1,000,000)
Hutchinson	376	71823	32.0
Salina	432	85826	16.0
Manhattan	230	40428	2.7
Lawrence	329	44087	15.2
Leavenworth	221	34044	10.0
Topeka	1195	183419	35.4
St.Joseph	797	120369	32.0
Columbia	367	63051	5.2
Jefferson City	282	48952	14.0
Springfield	959	178479	112.5
Joplin	390	72143	42.3
Cape Girardeau	249	56545	26.2
Grand Island	257	1006	7.7
Lincoln	1285	6455	78.4
Sioux City	891	149121	74.5
Waterloo	718	114155	206.4
Mason City	306	61999	29.3
Dubuque	566	86750	77.5
Fort Dodge	284	58365	31.8
Clinton	336	60140	54.0
Cedar Rapids	920	174429	301.2
Iowa City	334	57775	52.3
Ames	270	42342	14.0
Marshaltown	225	44457	72.9
Burlington	324	55761	79.6
Ottumwa	339	51861	70.7
Rapid City	424	96392	10.2
Sioux Falls	655	122415	66.5
Aberdeen	231	50367	6.0
St. Cloud	338	86417	19.2
Winona	249	47500	41.6
Rochester	407	91755	58.3
Austin	279	42245	58.4
Mankato	238	56257	31.5
Davenport	890	155242	92.8

Source: Census of Population, Census of Business, Census of Manufacturing.

APPENDIX V

DISTANCE MATRIX

	DOMINANT CENTERS							
SMALLER CITIES	Min	Mil	Chi	DM	Oma	Wic	KC	StL
Hutchinson	529	616	595	337	245	40	189	410
Salina	470	570	555	288	190	76	161	384
Manhattan	412	575	494	230	147	103	99	329
Lawrence	420	459	435	199	160	145	29	255
Leavenworth	400	439	415	179	140	165	18	245
Topeka	426	485	463	211	152	123	60	290
St. Joseph	359	414	359	142	108	192	50	252
Columbia	411	359	319	188	243	276	122	112
Jefferson City	442	378	335	221	268	273	133	101
Springfield	533	484	441	303	312	225	155	188
Joplin	541	538	487	312	290	157	132	249
Cape Girardeau	553	400	332	357	432	420	298	89
Grand Island	370	542	546	249	120	227	228	443
Lincoln	332	467	468	173	49	209	158	365
Sioux City	223	419	441	158	89	331	248	411
Waterloo	174	219	232	85	202	260	421	279
Mason City	128	253	282	104	194	429	286	335
Dubuque	207	138	157	155	279	479	308	262
Fort Dodge	161	306	329	74	123	373	239	334
Clinton	255	141	132	163	290	462	292	220
Cedar Rapids	214	198	200	98	221	418	249	240
Iowa City	230	200	184	100	411	412	240	220
Ames	205	285	293	24	353	355	200	278
Marshaltown	205	257	265	40	373	375	215	265
Burlington	289	222	188	130	242	388	211	257
Ottumwa	273	255	245	74	185	349	178	182
Rapid City	490	754	789	514	410	529	552	753
Sioux Falls	200	433	467	208	309	394	318	465
Aberdeen	252	539	589	360	155	532	476	621
St. Cloud	65	355	411	275	305	560	445	520
Winona	95	194	249	190	283	524	370	378
Rochester	79	224	273	173	255	500	354	380
Austin	90	238	280	146	229	470	325	365
Mankato	70	303	350	170	215	475	342	420
Davenport	210	160	132	148	273	444	272	208

APPENDIX V
(Continued)

SMALLER CITIES	Ind	Lou	Nas	DOMINANT CENTERS Mem	LR	OK	Tul	Den
Hutchinson	632	647	588	475	383	180	167	389
Salina	604	683	610	486	404	232	205	390
Manhattan	545	569	559	445	378	259	204	446
Lawrence	475	498	489	382	329	276	198	520
Leavenworth	465	498	494	385	338	295	215	525
Topeka	508	529	518	410	349	263	192	490
St Joseph	450	490	488	415	372	334	267	529
Columbia	333	348	352	293	289	368	270	661
Jefferson City	330	342	332	261	259	358	258	678
Springfield	418	405	359	225	173	264	162	652
Joplin	482	475	429	284	207	202	100	587
Cape Girardeau	249	213	167	151	229	455	359	839
Grand Island	674	678	689	594	533	380	349	359
Lincoln	548	595	610	525	485	367	317	439
Sioux City	551	618	660	608	476	488	433	481
Waterloo	362	439	513	517	532	555	469	674
Mason City	514	422	575	571	573	577	498	653
Dubuque	293	375	474	504	537	606	576	760
Fort Dodge	440	508	581	552	545	524	449	594
Clinton	252	336	427	461	498	587	490	774
Cedar Rapids	419	395	469	479	498	549	460	708
Iowa City	310	382	455	462	484	540	450	708
Ames	404	474	528	505	497	500	418	615
Marshaltown	378	450	510	495	497	514	430	643
Burlington	270	332	394	398	421	503	408	721
Ottumwa	329	390	439	422	430	478	385	665
Rapid City	611	675	999	927	862	662	660	315
Sioux Falls	593	668	701	658	627	552	502	498
Aberdeen	727	809	873	833	800	689	647	512
St. Cloud	570	660	747	752	752	718	651	690
Winona	404	498	594	619	637	668	581	743
Rochester	424	515	603	620	632	645	567	706
Austin	422	570	596	602	611	615	539	680
Mankato	495	579	659	650	644	620	550	633
Davenport	259	340	420	450	480	565	470	476

APPENDIX V

KEY TO DOMINANT CITIES

Min = Minneapolis	StL = St. Louis
Mil = Milwaukee	OK = Oklahoma City
Chi = Chicago	Den = Denver
DM = Des Moines	Ind = Indianapolis
LR = Little Rock	Lou = Louisville
Oma = Omaha/Council Bluffs	Nas = Nashville
Wic = Wichita	Mem = Memphis
KC = Kansas City	Tul = Tulsa

APPENDIX VI

FORTRAN STATEMENT
TO COMPUTE POTENTIAL

```
//WATFIV       JOB
$JOB           SL
      DIMENSION FMT(20),TITLE(20),POP(20),X(20)
   10 READ(5,1,END=90)TITLE, NOBS, NMET,FMT
    1 FORMAT(20A4/2I3/20A4)
      WRITE(6,2)TITLE,NOBS,NMET,FMT
    2 FORMAT('1' 20A4/' NOBS=',I4/' NMET=',I4/  FORMAT: ',20A4/' MET DAT
     *A'/)
      DO 20 I=1,NMET
      READ(5,FMT)POP(I)
   20 WRITE(6,3)I,POP(I)
    3 FORMAT(I4,F9.0)
      READ(5,4)FMT
    4 FORMAT(20A4)
      WRITE(6,5)FMT,TITLE
    5 FORMAT(' FORMAT= ',20A4/'1',20A4/)
      DO 30 I=1,NOBS
      READ(5,FMT)(X(J),J=1,NMET)
      SUM=0.0
      DO 40 J=1,NMET
      X(J)=POP(J)/(X(J)*X(J))
   40 SUM=SUM+X(J)
      WRITE(6,6)I,(X(J),J=1,NMET),SUM
    6 FORMAT(I5,7F11,3/5X,7F11.3/5X,7F11.3)
   30 WRITE(7,7)I,(X(J),J=1,NMET),SUM
    7 FORMAT(I3,'1',19A4/3X,'2',2A4)
      GO TO 10
   90 WRITE(6,8)
    8 FORMAT(',NORMAL END OF JOB')
      STOP
      END
$ENTRY
1960 POPULATION DATA
035016
(20X,F4.0)

     enter data here

$STOP
/*
```

Note: where the entry states, "1960 POPULATION DATA", this entry is changed to 1963 RETAIL SALES, 1963 VALUE ADDED, 1963 PAYROLL, for three separate runs to compute the potentials for each large center mass.

APPENDIX VII

COMPUTING FORMULAS

A

Regression Constants

$$a = \frac{\sum_{i=1}^{n} Y_i - b \sum_{i=1}^{n} X_i}{N} = \bar{Y} - b\bar{X}$$

$$b = \frac{\sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y})}{n \sum_{i=1}^{n} (X_i - \bar{X})^2}$$

where a = X intercept.
b = the regression coefficient or slope of the least-squares line.
X = the dependent variable.
$\bar{X}$ = the mean of the dependent variables.
Y = the independent variable.
$\bar{Y}$ = the mean of the independent variables.
n = the number of cases.

B

Formula for the F-Test
(given for 2 degrees of freedom)

$$F_{1,N-2} = \frac{r^2}{1-r^2} (N-2)$$

N = the number of cases.
r^2 = coefficient of determination.

APPENDIX VII

(Continued)

C

Formula for a First Order Partial Correlation

$$r_{ij \cdot k} = \frac{r_{ij} - (r_{ik})(r_{jk})}{1 - r_{ik}^2 \quad 1 - r_{jk}^2}$$

where i & j = the variables.
k = the number of categories into which X has been divided.
r = the regression coefficient.

D

Formula for F-test, Multiple Regression

$$F_{k,N-k-1} = \frac{R^2}{1-R^2} \quad \frac{N-k-1}{k}$$

where k = the number of categories into which X has been divided.
N = the number of cases.
R^2 = Multiple R Square or coefficient of determination.

*See Social Statistics by Hubert Blalock for more detailed discussions of these statistics.

RELATIVE LOCATION
AND INDUSTRIAL GROWTH

by

STEPHEN G. LEWIS

B.S., Kansas State University, 1977

AN ABSTRACT OF A MASTER'S THESIS

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MASTER OF ARTS

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1978

Factors influencing the location of industry is the central theme of this thesis. Technological innovations, particularly in the transportation field, have dramatically decreased the incentive to locate at raw material sites in favor of those locations in or near large urban centers. A review of more recent location literature revealed, since the 1950's, industry has been decentralizing from large urban agglomerations in favor of cities with a more rural setting. Despite the shift to smaller cities, accessibility to large urban centers appears to remain important.

Although this demand for relative accessibility has been noted by recent students of industrial location, their attempts at measuring it appear inadequate. The most prevalent method has been to correlate industrial growth with linear distance, measured in miles, between small cities and the nearest large center. A technique which would assess small city relative location in an area to all dominant economic and population agglomerations in a larger region would seem better than the method mentioned above. For this reason, potential, which is an aggregate measure of accessibility or the intensity of possible contact, was used to evaluate relative location.

The potential model was applied in this study to determine the degree to which industrial growth in small cities, ranging in population from 25,000 to 250,000, is associated with location relative to larger, dominant urban concentrations in the West North Central Region of the United States. Location potential was expressed in the form of potential surfaces described for several variables, to include population, retail sales, payroll in selected assembling and fabrication industries, and

value added by manufacturing. Based on these industrial potential surfaces, organizations (such as Chamber of Commerce groups) can assess their cities' abilities to attract industry on location alone. Furthermore, industrial location entrepreneurs can evaluate the relative location of each city on the isopotential surface.

If these organizations would be willing to accept the original hypothesis that industry is decentralizing yet seeking locations with "good" access to large urban centers, the isopotential maps would suffice as the basis for their industrial prospecting strategies and this study could have stopped at that point. However, since most city leaders would be unwilling to risk the economic fate of their communities on an unproven hypothesis, the industrial potential indexes were tested against two small city industrial growth variables, "change in the number of manufacturing employees" and "change in the number of manufacturing places," for the period from 1963 to 1972.

From these analyses, it was found that no single measure of relative location explained industrial growth in small cities. The highest r value obtained was .08 and at an insignificant level. Because no single measure of relative location explained the variation in industrial growth, the four potential indexes were combined to form a cumulative measure of relative location in a multiple regression equation to predict the industrial growth, dependent variables. Combined in this manner, the potential indexes were again ineffective predictors of industrial growth in small cities.

Because of the inability of situational variables (potential indexes) to explain industrial growth in small cities, three site variables, population, retail sales, and value added by manufacturing, were forced into

a regression equation ahead of the situational variables to determine: (1) if site explained more of the variation in industrial growth than situation; and (2) if situation contributed anything to that explanation. From this analysis, I learned that situation almost doubles the explaining power of small city site variables but even when combined, they do not explain the majority of the variation in industrial growth. Based on the results from my analyses, I can only conclude that industry in the Plain States seems to behave in a footloose manner.